Tracking survey:
ALICE central tracking overview

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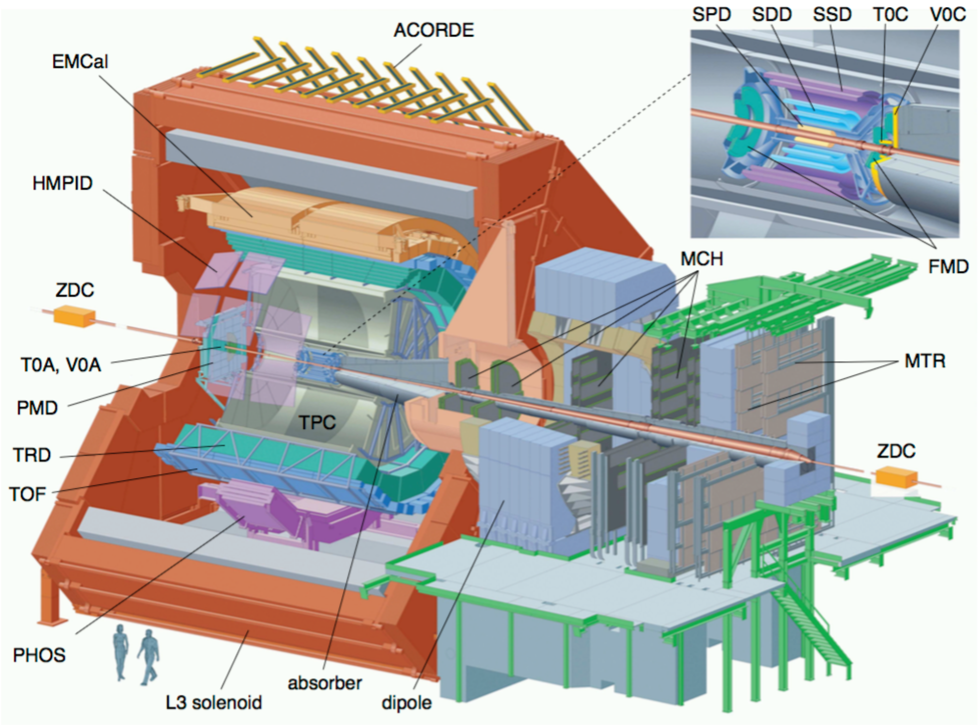
Prolog

- A broad discussion of the tracking problem and solutions for ALICE during their first run will be presented here.
- The following slides summarise material publicly available in:
  - Technical Design Report of the Time Projection Chamber (CERN/LHCC 2000/001)
  - Technical Design Report for the Upgrade of the ALICE Time Projection Chamber (CERN-LHCC-2013-020)
  - Performance of the ALICE Experiment at the CERN LHC (CERN-PH-EP-20140931)
  - ALICE: Physics Performance Report, Volume I (J. Phys. G: Nucl. Part. Phys. 30 2004 1517-1763)
  - The ALICE experiment at the CERN LHC (2008 JInst 3 S08002)
  - The ALICE data flow: from calibration, to QA, through reconstruction (LHCP2016, M. Ivanov)
- The information presented here may be an underestimated representation (i.e. not complete) of the solution of ALICE for tracking. I apologise in advance.

ALICE detector



Central tracking detectors

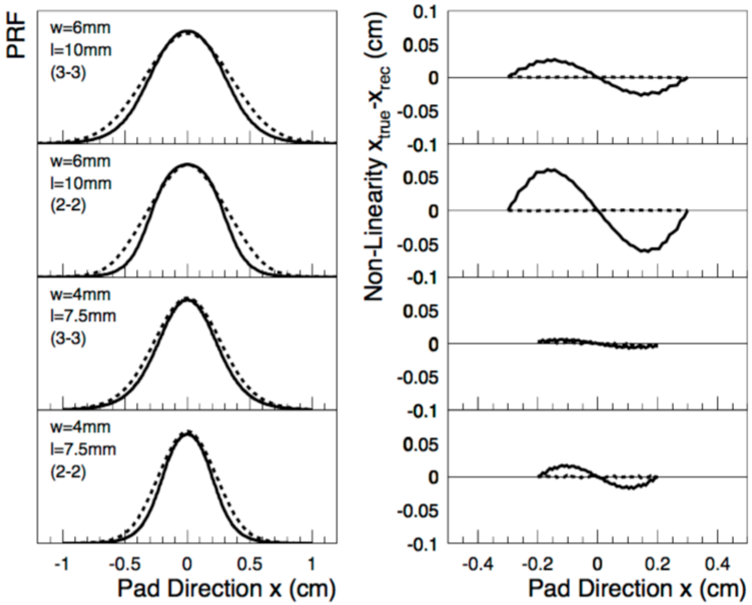
- Inner Tracking System (ITS)
  - 6 Si layers (2xpixels, 2xdrift, 2xstrip)
- Time Projection Chamber (TPC)
  - Ne-based & MWPC
- Transition Radiation Detector (TRD)
  - TR+Xe & MWPC
- Time Of Flight (TOF)
  - MRPC

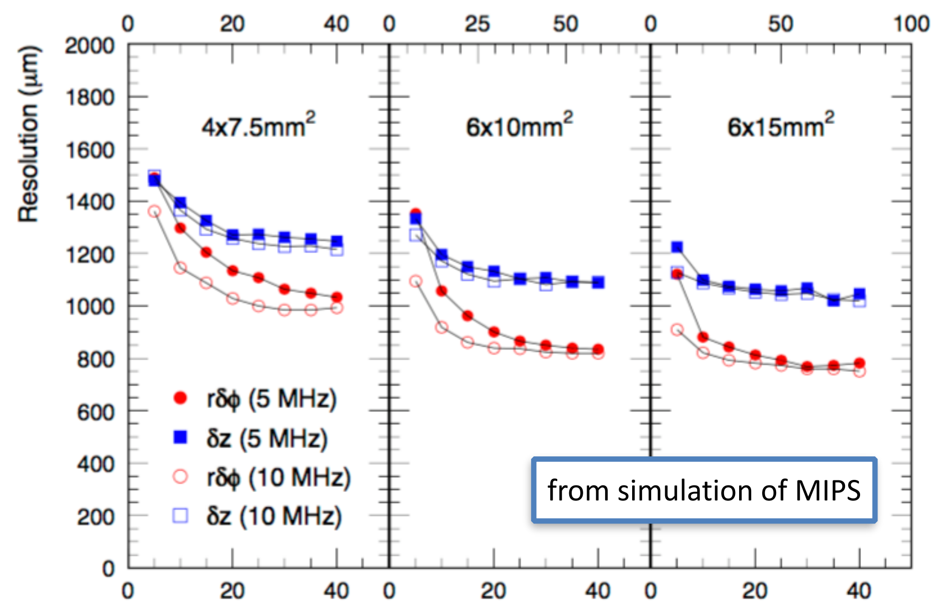
Full azimuthal coverage
pseudo rapidity overlap 0.9

Clusters in TPC

	Pad size [mm^2]	Number of rows	Number of pads
Inner chamber ($84.1 < r < 132.1$ cm)	4×7.5	64	5 732
Outer chamber ($134.6 < r < 198.6$ cm)	6×10	64	6 038
Outer chamber ($198.6 < r < 246.6$ cm)	6×15	32	4 072
TPC total		160	570 312

- Clusters use 2D centre of gravity (pad-row and time)
- At high densities, take into account cluster structure





Tracking algorithm

- Kalman filter is used
  - Depends critically on initial seed values and covariances
- Seeding is done twice: first, using primary vertex; second, assuming track originated elsewhere
- Procedure repeats several times moving closer to centre

Track following (3 steps)

STEP 1a

- Starts combining space-points from outermost padrow
- Propagate state vector of the track parameters and covariances to the next padrow
- Add to the inverted covariance matrix a noise term (representing information lost due to stochastic processes: MS, ELF, etc)
- If space-point compatible with the the track prolongations found, we add this and update the seed.
- Remove primary vertex from constraints
- Keep moving until innermost layer is reached

Track following (3 steps)

STEP 1b

- Tracks are propagated to the outer layer of the ITS
- Start with the highest momentum tracks (to reduced comb)
- Tracks are followed through ITS without primary vertex constraints.
- Whenever more than one cluster is compatible (window half width=4sigma), all possibilities are followed independently (i.e. each TPC track can have several candidate paths in ITS).
- Optionally an additional track finding step using only ITS space points that are not associated to any found track.

Track following (3 steps)

STEP 2

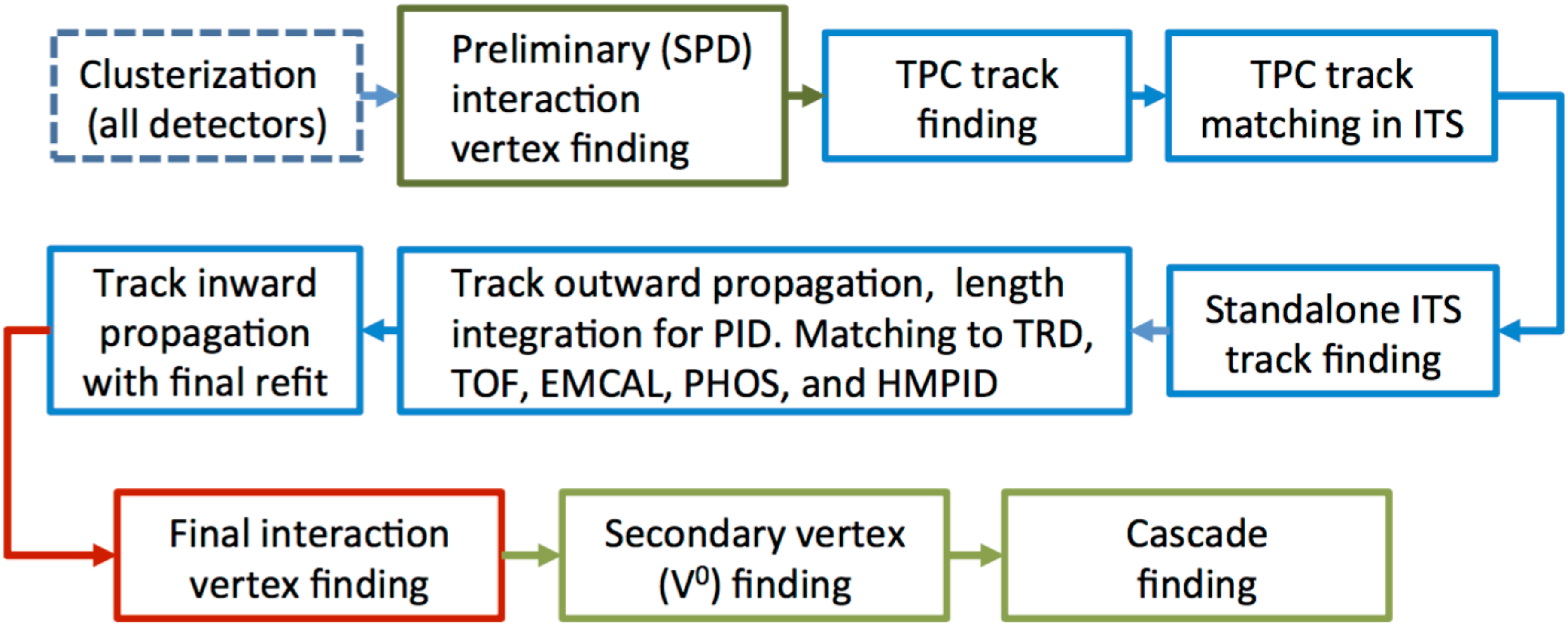
- When ITS tracking is completed, Kalman filter is reversed.
- Following goes from inner layer of ITS to outer layer of TPC, then continue to TRD, TOF, HMPID and space-points in CPV in front of PHOS.

Track following (3 steps)

STEP 3

- Finally Kalman is reversed one more time and refit all tracks from outside inwards.

Tracking flow in a nutshell



Performance of tracking algorithm

Track Finding Efficiency

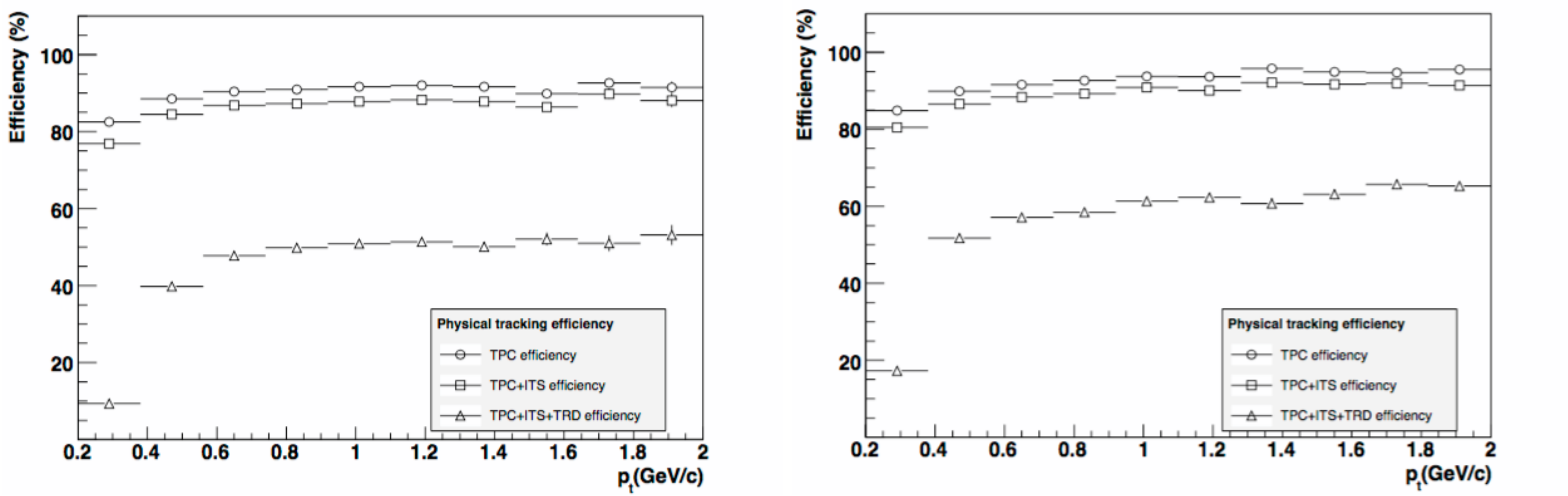


Figure 8.5: Physical track-finding efficiency for different combinations of the tracking detectors. Left: Central Pb–Pb collisions ($dN_{ch}/d\eta = 6000$). Right: pp collisions.

Noticed that the efficiency is driven by the amount of dead zones in the different detectors. For TRD, additionally, the interaction with material and decays play a role

Performance of tracking algorithm

PT Resolution

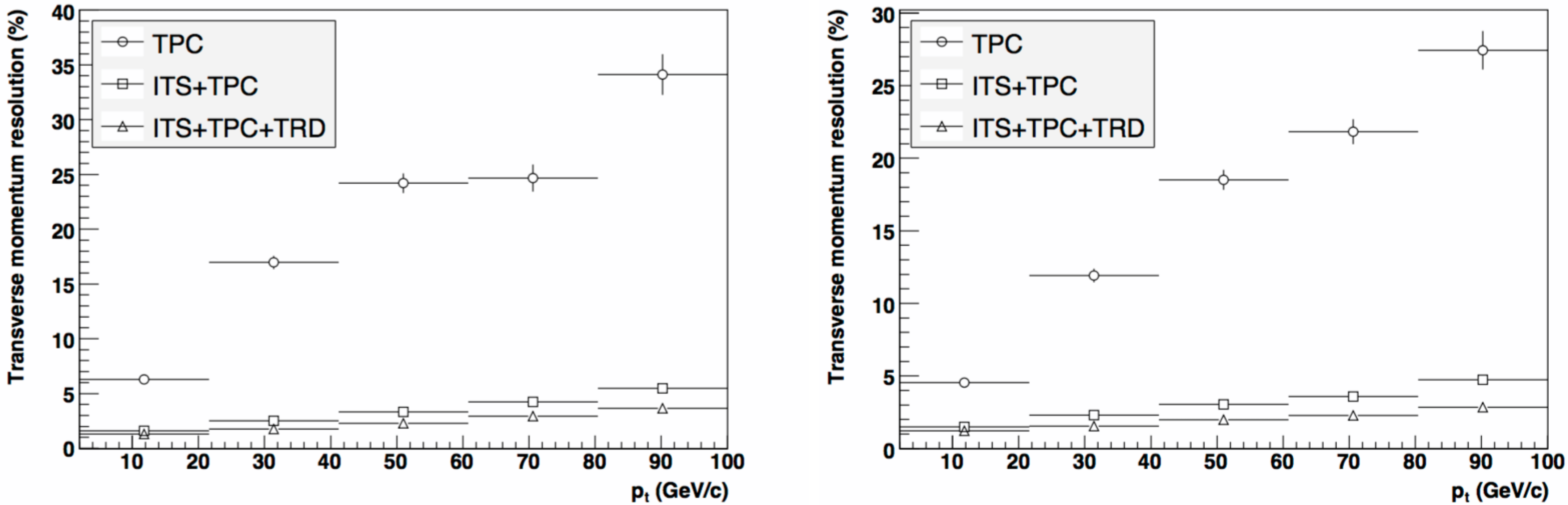


Figure 8.6: Transverse-momentum resolution for different combinations of the tracking detectors. Left: Central Pb–Pb collisions ($dN_{ch}/d\eta = 6000$). Right: pp collisions.

Noticed that the resolution improves with the extension from larger tracking length

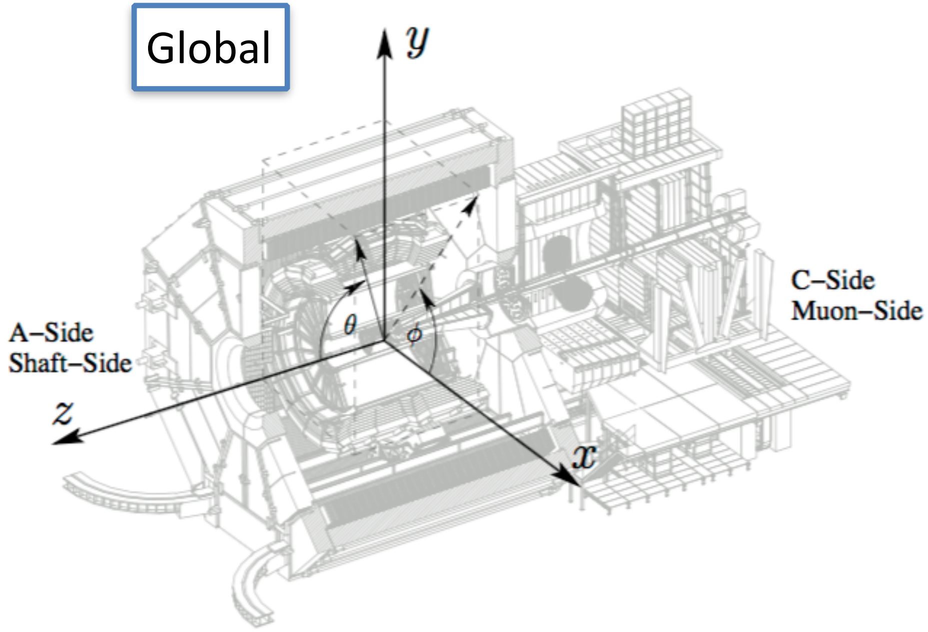
Outlook

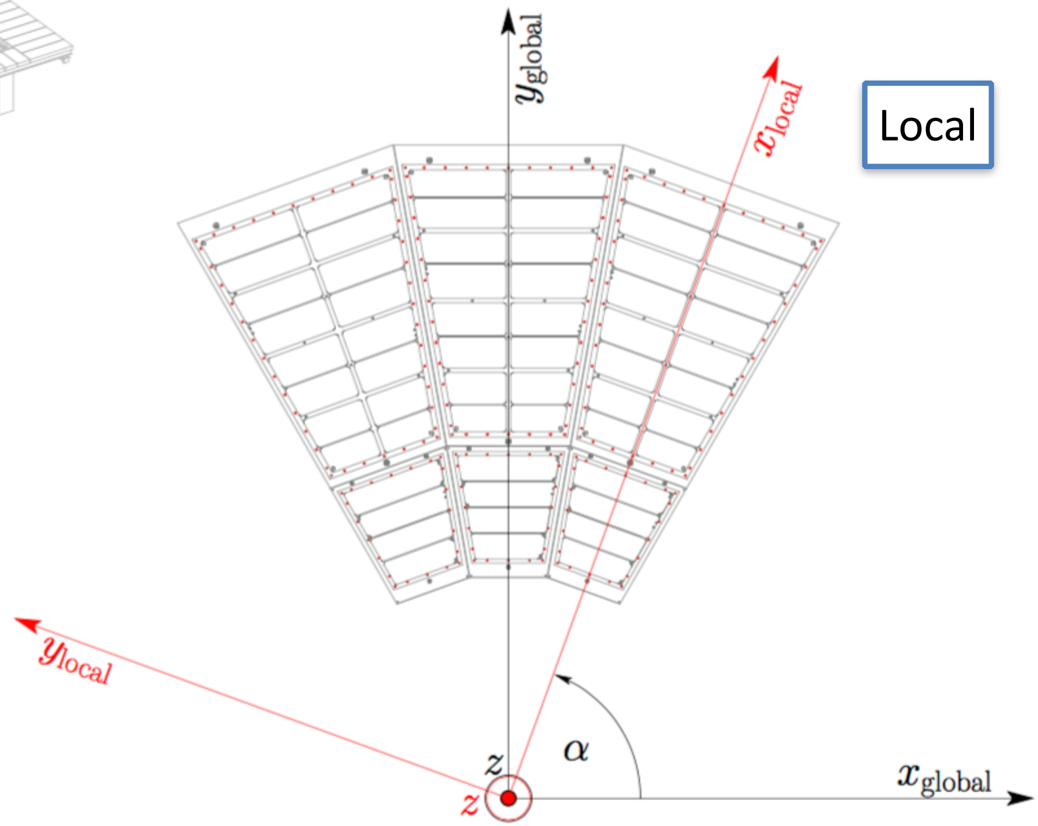
- For Run1 and Run2, ALICE has employed successfully the Kalman filter plus a reiterative multistage flow methodology to solve the tracking in the central region.

- Not so clear if after upgrade they will continue this path. Other technologies are being explored: Hough transformation (see Phys Part and Nucl Lett 2016, Vol 13, No 5, 654-658)

Coordinate systems in ALICE

Global





Local